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PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION, OHIO RIVER--ETC(U)
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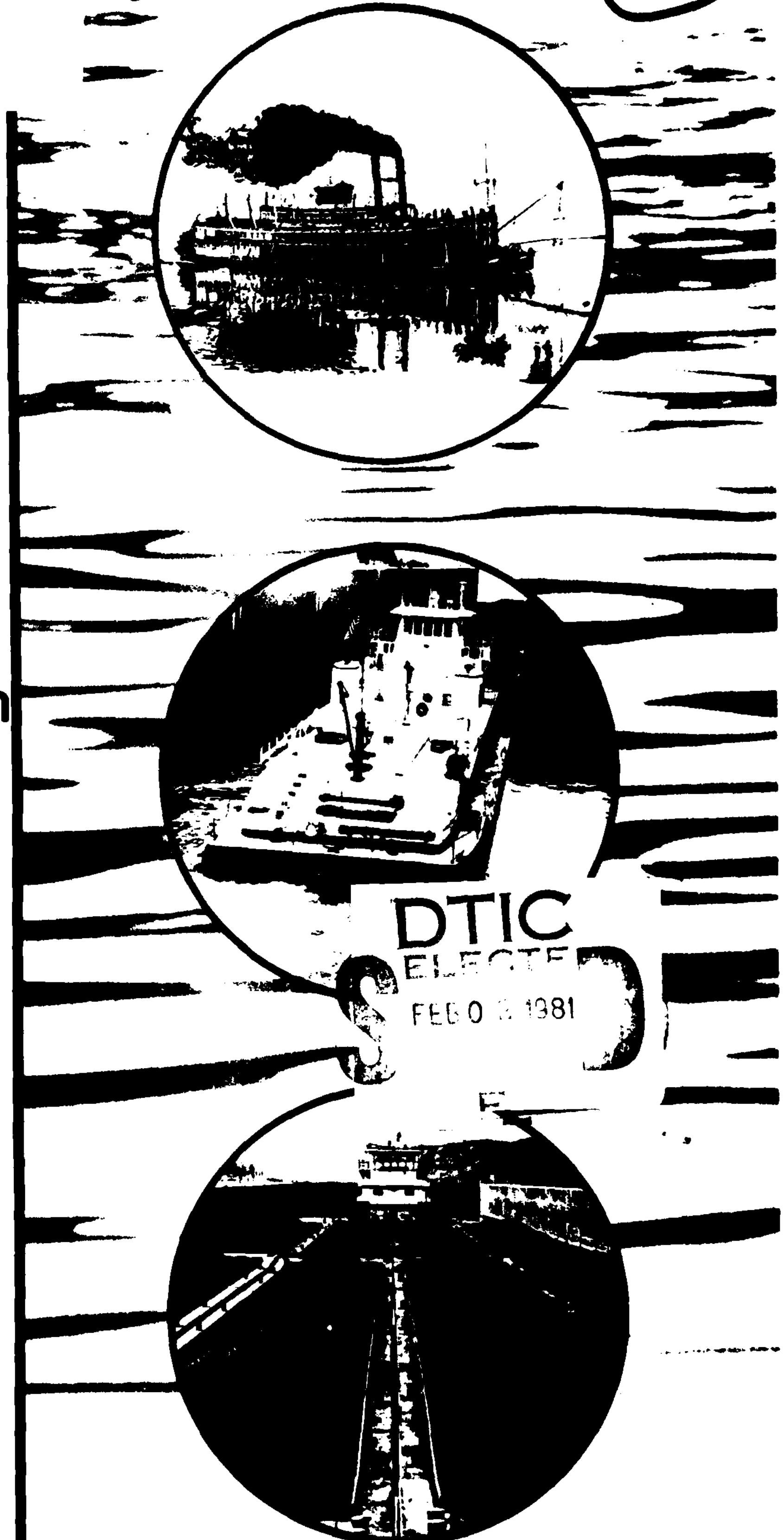
Projections Of Demand For Waterborne Transportation

Ohio River Basin
1980 - 2040

Volume 5

Crude Petroleum



U. S. Army Corps of Engineers
Ohio River Division
Cincinnati, Ohio

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A094 361	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Projections of Demand for Waterborne Transportation, Ohio River Basin 1980, 1990, 2000, 2020, 2040; Vol. 5, Group III: Crude Petroleum A094 360		5. TYPE OF REPORT & PERIOD COVERED Vol. 5 of 17
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s) DACW69-78-C-0136
9. PERFORMING ORGANIZATION NAME AND ADDRESS Robert R. Nathan Associates, Inc. Consulting Economists 1301 Pennsylvania Ave., N.W. Washington, DC 20004		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Ohio River Basin Navigation Studies
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Corps of Engineers, Ohio River Div. ATTN: Navigation Studies Branch, Planning Div. P.O. Box 1159, Cincinnati, OH 45201		12. REPORT DATE December 1980
		13. NUMBER OF PAGES 42
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) U.S. Army Corps of Engineers, Huntington District P.O. Box 2127 Huntington, WV 25721		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Bulk cargo
Commodity resource inventory
Economic development
Economic forecasting
Inland waterways
Market demand analysis
Modal split analysis
Ohio River Basin
River basin development
Traffic surveys
Crude oil
Petroleum transportation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River Basin Navigation System. Each of the studies considers existing waterborne commerce and develops a consistent set of projects of future traffic demands for all of the navigable waterways of the Basin. Each report contains information on past and present waterborne commerce in the Basin and projections by commodity groups and origin-destination areas from 1976 to at least 1990.

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(Continued from #20)
The three study projections, in conjunction with other analytical tools and system information, will be used to evaluate specific waterway improvements to meet short and long-term navigation needs. The output from these studies will serve as input to Corps' Inland Navigation Simulation Models to help analyze the performance and opportunities for improvement of the Ohio River Basin Navigation System. These data will be used in current studies relating to improvement of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, the Cumberland River and the Tennessee River, as well as other improvements.

This document is volume 5 of the 17 volume report shown below.

The study included a Commodity Resource Inventory, a Modal Split Analysis and a Market Demand Analysis. The work included investigation and analyses of the production, transportation and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of and within the Ohio River Basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A study summary aggregates the commodity group totals for each of the several projections periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin. The study results are presented in the following 17 documents:

Volume	Subject Title	
1	Study summary	
2	Methodology	
3	Group I:	Coal and coke
4	Group II:	Petroleum fuels
5	Group III:	Crude Petrol.
6	Group IV:	Aggregates
7	Group V:	Grains
8	Group VI:	Chemicals and chemical fertilizers
9	Group VII:	Ores and Minerals
10	Group VIII:	Iron ore, steel and iron
11	Group IX:	Feed and food products, nec.
12	Group X:	Wood and paper products
13	Group XI:	Petroleum products, nec.
14	Group XII:	Rubber, plastics, nonmetallic, mineral, products, nec.
15	Group XIII:	Nonferrous, metals and alloys, nec.
16	Group XIV:	Manufactured products, nec.
17	Group XV:	Other, nec.

Additionally, an Executive Summary is available as a separate document.

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GROUP III, CRUDE PETROLEUM.

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PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION, OHIO RIVER BASIN, 1980, 1990, 2000, 2020, 2040. Volume 5.

Prepared for

U.S. ARMY CORPS OF ENGINEERS
OHIO RIVER DIVISION, HUNTINGTON DISTRICT

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Contract No. DACW69-78-C-0136

by

Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

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Library cataloging information:

Robert R. Nathan Associates, Inc.
Projections of demand for waterborne transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040 / Prepared for the U.S. Army Corps of Engineers, Huntington District ... by Robert R. Nathan Associates, Inc., December 1980. Cincinnati, Ohio : U.S. Army Corps of Engineers, Ohio River Division, 1980.
17 v. : ill. ; 28 cm.
Contract DACW69-78-0136.
"...*one of three independent but* complementary studies of future freight traffic on the Ohio River Basin Navigation System."

CONTENTS: v.1. Study summary.--v.2. Methodology.--v.3. Commodity groups .

1. Shipping--Ohio River Basin. 2. Inland water transportation--Ohio River Basin--Statistics. 3. Ohio River Basin. I. United States. Army. Corps of Engineers. Ohio River Division. II. United States. Army. Corps of Engineers. Huntington District. III. Title.

HE597.03N3 OCLC no. 7030444

PREFACE

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River basin navigation system. Each of the studies considers existing waterborne commerce and develops a consistent set of projections of future traffic demands for all of the navigable waterways of the basin. Each report contains information on past and present waterborne commerce in the basin with projections by commodity group and origin-destination areas from 1976 to either 1990 or 2040.

The three projections, in conjunction with other analytical tools and waterway system information, will be used to evaluate specific waterway improvements required to meet short and long-term navigation needs. The output from these studies will serve as input to Corps inland navigation simulation models to help analyze the performance and requirements for improvements of the Ohio River basin navigation system. These data will be used in current studies relating to improvements of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, and the Tennessee River, as well as for other improvements.

The reports on the three studies are referred to as the "CONSAD," the "BATTELLE," and the "NATHAN" reports. The latter and final report was completed in November 1980. It was prepared for the Corps of Engineers by Robert R. Nathan Associates, Inc., Consulting Economists, Washington D.C. This study encompasses the period 1976-2040, and is by far the most detailed of the three.

The "CONSAD" report, completed in January 1979, was prepared for the Corps by the CONSAD Research Corporation of Pittsburgh, Pennsylvania. The study and the 1976-1990 projected traffic demands discussed in that report were developed by correlating the historic waterborne commodity flows on the Ohio River navigation system, with various indicators of regional and national demands for the commodities. The demand variables which appeared to best describe the historic traffic pattern for each of the commodity groups was selected for projection purposes. The projected values for the demand variables are based upon the 1972 OBERS Series E Projections of National and Regional Economic Activity. The OBERS projections serve as national standards and were developed by the Bureau of Economic Analysis of the U.S. Department of Commerce, in conjunction with the Economic Research Service of the Department of Agriculture.

The "BATTELLE" report was completed in June 1979, and was prepared for the Corps by the Battelle Columbus Laboratories, Columbus, Ohio. The study and the 1976-1990 traffic projections discussed in that report were developed by surveying all waterway users in the Ohio River Basin through a combined mail survey and personal interview approach. The purpose of the survey was to obtain an estimate from each individual shipper of his future commodity

movements, by specific origins and destinations, as well as other associated traffic information. All identifiable waterway users were contacted and requested to provide the survey information. In addition, personal interviews were held with the major shippers. The responses were then aggregated to yield projected traffic demands for the Ohio River navigation system.

The "NATHAN" report presents the findings of a commodity resource inventory, a modal split analysis and a market demand analysis. The work included investigation and analyses of the production, transportation, and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of, and within the Ohio River basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A Study Summary and an Executive Summary present appropriately abbreviated discussion and findings resulting from these analyses. The Study Summary aggregates the commodity group totals for each of the several projection periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin.

The "NATHAN" report, "Projections of Demand for Waterborne Transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040" consists of the following volumes:

Subject Title	Number of Pages	Volume Number
Study Summary	220	1
Methodology	118	2
Group I: Coal and Coke	134	3
Group II: Petroleum Fuels	66	4
Group III: Crude Petroleum	42	5
Group IV: Aggregates	64	6
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Group XIV: Manufactured Products Nec.	35	16
Group XV: Others, Nec.	48	17

Additionally, an Executive Summary is available as a separate document.

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PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION OHIO RIVER BASIN 1980, 1990, 2000, 2020, 2040

Group III: Crude Petroleum

Prepared for
U.S. Army Corps of Engineers
Huntington District
Contract No. DACW69-78-C-0136

by
Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

November 1980

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I. INTRODUCTION

Group III, crude petroleum, has become a relatively insignificant commodity in terms of tonnage that is transported in the Ohio River System (ORS). In 1969, with respect to total ORS waterborne movements, Group III ranked fifth among the 15 commodity groups analyzed in this study. By 1976, crude petroleum was ranked eleventh, and during the period, 1969-76, crude petroleum accounted for less than 3 percent of total ORS traffic. In the future, it will account for much less.

The areas within the Ohio River Basin (ORB) for which projections of Group III consumption, production and movements have been made are designated as Primary Study Areas (PSAs). The PSAs for Group III are those U.S. Department of Commerce Bureau of Economic Analysis Areas (BEAs) and area segments (aggregations of counties within a BEA) which are origins or destinations of Group III waterborne movements. A map showing Group III PSAs is presented in the appendix to this report.

In addition to the PSAs, external areas linked to the ORB through waterborne commerce have been identified. Areas (BEAs) outside the ORB which are destinations of waterborne Group III movements originating in the ORB are designated as Secondary Consumption Areas (SCAs). Areas (BEAs) outside the ORB which are origins of Group III waterborne movements destined to the CRB are designated as Secondary Production Areas (SPAs).

A. Description of Commodity Group III

This group is composed of a single commodity, crude petroleum, which is designated as Waterborne Commerce Statistics Code 1311. There are different types and qualities of crude oils: light versus heavy crudes, and low sulfur versus high sulfur crudes. Light crudes yield a large proportion of valuable fuels, such as motor gasoline and jet fuels, while heavy crudes yield a high

proportion of residual fuels. The refining process for high sulfur crudes generally creates serious pollutants. With increasing EPA environmental quality controls, only refineries with special pollution control equipment will be able to refine high sulfur crudes in the future.

In 1978, the Petroleum Administration for Defense District II (PADD II), which includes major crude oil production areas in the Ohio River Basin, reported an excess of high sulfur refining capacity.[1] Thus, increases in the supply of high sulfur, relative to low sulfur, crude oils are not apparent constraints on refineries in the ORB. This report, therefore, deals with the consumption and supply of crude petroleum as a homogenous commodity.

B. Existing Waterway Traffic Flows

The total inbound, outbound and local waterborne movements of crude petroleum in the ORS were reported at 6.6 million tons in 1969. Movements increased to a peak level of nearly 8 million tons in 1971, and then decreased to 664.5 thousand tons in 1976 (Table 1). The decline resulted from the total disappearance of local movements. This occurred partly because of the decrease in crude oil production in the PSAs, but mostly because of the development of a more extensive pipeline system.

Outbound waterborne movements of crude oil occurred randomly and in small amounts during the 1969-76 period. Inbound shipments, on the other hand, showed a steadily increasing trend.

Table 2 presents the BEA-to-BEA waterborne flows of crude oil for 1976. As shown, only a small number of origins and destinations are involved in the water transportation of crude petroleum in the ORS.

C. Summary of Study Findings

From 1969 to 1976, the consumption of crude petroleum in the study area increased from 1.4 million tons to 1.9 million tons. Production, on the other hand, decreased rapidly and steadily throughout the period. In 1976, crude oil production in the study area was estimated at only 48 percent of the 1969 level.

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1. For definition of the PADDS, see Appendix Map A-2. PADD II crude run is 1,153 mb/d; capacity is 1,718 mb/d. Robert R. Nathan Associates, Inc., Alaska North Slope Crude Oil: An Economic and Financial Assessment of Distribution Alternatives (Washington, D.C.: RRNA, 1978), p. 44.

Table 1. Ohio River System: Waterborne Shipments of Crude Petroleum Inbound, Outbound, and Local Movements, 1969-76

(Thousands of tons unless otherwise specified)

Commodity and type of movements	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Total crude petroleum	6,593.1	7,090.1	7,956.5	7,811.1	4,220.4	643.9	867.1	664.5	(28.0)
Inbound	22.5	25.6	33.2	25.9	134.6	393.0	471.9	664.5	62.2
Outbound	42.7	--	--	--	--	7.5	70.2	--	--
Local	6,528.0	7,064.5	7,923.3	7,785.2	4,085.8	243.3	324.9	--	a

a. No tonnage reported in 1976.
Source: Compiled by RRNA from Waterborne Commerce by Port Equivalents, 1969-76, supplied by U.S. Army Corps of Engineers.

Table 2. Ohio River Basin: Waterborne Commerce by BEA, 1976
Group III: Crude Petroleum

(Thousands of tons)

Origin	Total	Destination: ORB BEAs	BEA 55	BEA 64	BEA 66	Non-ORB BEAs
Total	664.5	664.5	497.6	163.6	3.3	--
ORB BEAs	--	--	--	--	--	--
--	--	--	--	--	--	--
Non-ORB BEAs	664.5	664.5	497.6	163.6	--	**Traffic external to Ohio River System**
BEA 38	41.2	41.2	41.2	--	--	
BEA 77	85.7	85.7	--	85.7	--	
BEA 114	25.6	25.6	--	25.6	--	
BEA 138	508.7	508.7	456.4	52.3	--	
BEA 140	3.3	3.3	--	--	3.3	

Source: U.S. Army Corps of Engineers, Waterborne Commerce by Port Equivalents, revised 1976.

The combined effect of rising consumption and declining production resulted in an increasing amount of oil being transported into the study area. Inbound barge transportation increased from 23 thousand tons in 1969 to 664.5 thousand tons in 1976.

The continued significance of the waterways in transporting crude petroleum will depend on the availability of highly competitive pipelines and the production/consumption gap in the PSAs. It is expected that the production of crude oil in the PSAs will decrease slightly in the 1976-90 period, and will then drop rapidly in the following decades. Consumption, on the other hand, will likely increase until the late 1980s and decrease rapidly thereafter.

Total inbound shipments by the waterway are projected to increase from 664.5 thousand tons in 1976 to a peak level of 847.1 thousand tons in 1980. Then they are expected to decrease steadily to 344.1 thousand tons in 2040.

The local waterborne movements of crude oil, which decreased to a negligible level in 1976, and the outbound movements, which were never significant, are both expected to be insignificant in the future.

II. MARKET DEMAND ANALYSIS

Oil refineries are the only consumers of crude petroleum. In the past decades, with a brief pause in 1974 following the Arab oil embargo, both U.S. and PSA consumption increased.

A. Market Areas

In addition to local demand for Group III commodities produced in the PSAs, demand is also generated by Secondary Consumption Areas (SCAs) located outside the ORB. These SCAs are defined as BEAs which are the destinations of waterborne crude petroleum movements originating in the Ohio River Basin.

A-1. Primary Study Areas (PSAs)

In 1976, only four BEAs in the ORB were sites of refineries in operation. Only three PSAs in the ORB are, and will continue to be, the ultimate origins or destinations of waterborne crude petroleum movements. Appendix Table A-1 presents the BEAs or BEA segments which constitute the PSAs for crude petroleum, and for which crude petroleum consumption has been analyzed and projected.

A-2. Secondary Consumption Areas (SCAs)

SCAs are defined as those areas outside the ORB which receive waterborne shipments from the ORB. There is no significant SCA for crude petroleum. In 1976, there were no outbound shipments of crude petroleum.

B. Commodity Uses

Crude petroleum is used in oil refineries as the input for the production of various petroleum fuels and products. The 1976 data

show that an average barrel of crude oil refined in the United States yielded approximately 51 percent gasoline, 7 percent naphthas, 22 percent distillate fuel oil, and 10 percent residual oil. The remainder was kerosene, petrochemical feedstocks, lubricants, and various other petroleum products.

C. Consumption Characteristics

Consumption characteristics of crude petroleum are determined by factors influencing commodity demand. Since crude oil is a primary product, its demand is dependent on the demand for motor gasoline, jet fuels, heating oils, petrochemical feedstocks, etc. Factors influencing the demand for these products are further discussed in the Petroleum Fuels (Group II) Report and Petroleum Products (Group XI) Report.

Generally, changes in income, population, prices of alternative energy forms, the availability of substitutable resources and the level of technology all have important impacts on the demand for crude oil. The effects are cumulative and interdependent in many cases.

Population and income have significant impacts on energy consumption, in general, and on petroleum consumption, in particular. At the national level, the growth of population and income can be approximated by the rate of Gross National Product (GNP) or economic growth. The U.S. Department of Energy has predicted that, for the 1975-85 period, a real GNP growth rate of 3.8 percent per year will likely be associated with an average annual growth rate of 2.6 percent in energy consumption. If a GNP growth rate of 4.2 percent is assumed, energy consumption growth will increase to 3.1 percent per annum.[1]

The supply of crude petroleum also places a constraint on energy consumption. In the short run, a low domestic supply of petroleum can be supplemented by imports. However, other things being equal, higher energy prices for imported crude oil and larger trade deficits will have a negative impact on GNP growth and decrease U.S. energy consumption. In the long run, the import of

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1. Department of Energy, Energy Information Administration, Annual Report to Congress, (Washington, D.C.: GPO, 1977), Vol. II, p. xix.

petroleum is expected to decrease as the world oil reserves are depleted. Oil shortages and high petroleum fuel prices will encourage the use of coal, nuclear, solar and other energy fuels. As a result of new technologies, the supply of these energy fuels is expected to increase to meet higher demands which, in turn, will be encouraged by the high costs of oil. This demand-supply mechanism means that in the long run, the consumption of crude oil will be strongly governed by the available supply.

D. Existing Aggregate Demands

In 1976, oil refineries in the United States processed 4.9 billion barrels, or 746 million tons, of crude oil, of which 61 percent was domestic crude oil and lease condensate and 39 percent was imported from foreign countries.[1] In the PSAs, crude oil is consumed by refineries located in BEAs 55 (Evansville), 64 (Columbus) and 66 (Pittsburgh). Total consumption in the PSAs, except for a slight decline in 1970 and 1971, increased steadily from 1.4 million tons in 1969 to 1.9 million tons in 1976 (Table 3).

Preliminary data show that despite a large increase in the average price of crude oil, consumption of crude oil in the nation and in the PSAs further increased in 1977 and 1978.[2]

E. Forecasting Procedures and Assumptions

Numerous national projections of crude petroleum have been made by individuals, research institutions and government agencies. All of the forecasts consider the demand for energy in terms of British Thermal Units (BTUs) which are allocated to various energy sources, including coal, petroleum, nuclear, and hydroelectric. Few projections are made for state or local entities.

The most notable projections have been made by the U.S. Department of Energy, Energy Information Administration (EIA).[3] EIA projections generally have been recognized as official energy projections for the United States.

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1. U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1976 ed. (Washington, D.C.: GPO, 1979), p. 6.
2. Average domestic price per barrel of oil increased from $6.87 in 1974 to $7.67 in 1975, and $8.18 in 1976; Ibid., p. 17.
3. U.S. Department of Energy, Energy Information Administration, Annual Report to Congress (Washington, D.C.: GPO, 1979), Vol. II.

Table 3. United States and Ohio River Basin: Consumption of Crude Petroleum, by BEAs or BEA Segments,[a] Estimated 1969-76

(Thousands of tons)

BEA or BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
United States	578,002.0	591,601.0	608,784.0	639,998.0	683,060.0	667,698.0	686,203.0	745,671.0
Primary Study Areas	1,370.7	1,210.6	1,252.5	1,403.9	1,589.3	1,602.5	1,707.9	1,880.2
BEA 55: Evansville, IN	803.4	620.7	624.3	671.5	707.9	700.3	831.8	953.5
BEA 64: Columbus, OH	235.2	238.5	252.0	263.0	191.3	214.4	212.3	225.1
BEA 66: Pittsburgh, PA	332.1	351.4	376.2	469.4	690.1	687.8	663.8	701.6

Note: Consumption by BEAs and BEA segments is based on state refinery consumption figures distributed among BEA regions on the basis of the 1969-76 distribution of state petroleum refinery capacity of operating plants among BEAs and BEA segments. Annual distribution was estimated as the average of distributions obtained for January 1 of each year and the following year. In 1969 distribution of capacity was assumed equal to January 1, 1970 distribution.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. Department of the Interior, Bureau of Mines, "Crude Petroleum and Petroleum Products," Minerals Yearbook, 1969-76 eds., and "Petroleum Refineries in the United States and Puerto Rico," Mineral Industry Surveys, January 1, 1970-76.

The EIA projection procedure, which encompasses differing viewpoints, is aimed at providing general energy forecasts. Thus, a series of projections was developed using different rates of national economic growth, different levels of recoverable energy resources, and various real prices of imported oil.[1]

Three levels of economic growth were taken from macroeconomic forecasts by Data Resources, Inc. (DRI) to predict the short-run energy demand. For the mid-term projections (to 1985 and 1990), the DRI forecasts were incorporated into the Project Independence Evaluation System (PIES)[2] to obtain basic national level projections associated with three assumed levels of energy supply. The medium projection (Series C) was selected to project ORB consumption of crude petroleum in 1980 and 1990.

The EIA projection of U.S. crude oil consumption was allocated to the PSAs on the basis of Oak Ridge National Laboratory (ORNL) projections for 1980 and 1985 of the energy supply and demand patterns of nine U.S. Census regions, 50 states, and 173 BEAs.[3] The supply and demand projections were made for seven fuel types and four final consuming sectors.[4] ORNL selected the "business as usual" scenario projected by the Federal Energy Administration in National Energy Outlook, 1976. The regionalization procedure used historical and projected regional characteristics to allocate national production and consumption totals. The regional economic and demographic characteristics were taken from OBERS projections prepared by the U.S. Department of Commerce for the U.S. Water Resources Council. Energy consumption characteristics for each BEA

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1. For additional information on EIA projection methodology, see Ibid., pp. xv-li.

2. The PIES is a model of the technologies, costs and geographical locations which affect energy commodities from the point of discovery, through production, transportation, and conversion to more useful forms and ultimately to consumption by all sectors of the economy (see Federal Energy Administration, "Appendix A," National Energy Outlook, Washington, D.C.: GPO, 1976).

3. Oak Ridge National Laboratory, Energy Availabilities for State and Local Development: Projected Energy Patterns for 1980 and 1985 (Oak Ridge, TN: ORNL, 1978).

4. The seven fuel types are crude oil, distillate oil, residual oil, gasoline, other hydrocarbons, natural gas and coal. The four final demand sectors include residential and commercial, industrial, transportation, and miscellaneous uses.

are assumed to be determined by the BEA's share of the overall state level of activity. Additional variables are assumed to be either uniform across the state (e.g., heating degree days) or to be unimportant relative to differences in the level of activity (e.g., per capita income or regional price differences).[1]

A possible shortcoming of the Oak Ridge report is that the U.S. energy projections were derived from the National Energy Outlook. These projections have since been revised in the Annual Report to Congress, 1977. The latest national data from the Annual Report were used with 1980 regional allocation factors provided by Oak Ridge to estimate the PSA consumption of crude oil in 1980. The major drawback of this approach is that it does not allow for the feedback effects of higher energy consumption which are incorporated into the Oak Ridge regional distribution model. However, a revision process would require substantial theoretical and computer work in cooperation with the ORNL. This process probably would have only minimal impacts on the projections of ORS waterborne Group III movements.

Once the 1980 crude oil consumption in BEAs served by the ORS was projected, the average annual growth rate for each BEA in the 1976-80 period was estimated and applied to the appropriate BEA segments. Thus, 1980 crude oil consumption estimates for each PSA were obtained. The 1990, and later, crude oil consumption projections were made by the same method and by applying 1985 allocation factors.

F. Probable Future Demand

The future demand for energy, and for crude petroleum in particular, will largely depend on national conservation programs and on the price and availability of domestic and imported crudes. Nearly seven years have elapsed since the 1973 oil embargo which resulted in a quadrupling of world oil prices. However, until very recently, little progress has been made in reducing the imports of oil. As a matter of fact, crude oil imports have continued to increase. By 1977, the total imports of crude petroleum stood at 6.6 million barrels per day -- double 1973 imports.[2] Expansion in

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1. Oak Ridge National Laboratory, Energy Availabilities for State and Local Development: A Methological Data Overview (Oak Ridge, TN: ORNL, 1978), p. 25.
2. U.S. Department of Energy, Energy Information Administration, Annual Report to Congress (Washington, D.C.: GPO, 1977), p. 23.

the use of coal as a primary energy source and as a substitute for oil has not occurred. Nuclear energy has grown substantially. However, environmental concerns constitute serious limitations on the growth of this industry. The recent incident at the Three Mile Island plant in Pennsylvania constituted a considerable setback for nuclear energy.

While funds from various sources are being channeled to the field of energy research for new technologies, new energy sources can at best only be expected to provide gradual replacements for the declining supply of oil which is predicted to occur in the 1990s.

The availability of new energy sources, the lower supply of crude oil in the PSAs, and the negative effects of high oil prices on petroleum fuels and products will cause a decrease in the rate of growth in the oil refining industry during the next decade. The consumption of crude petroleum in the PSAs is also projected to follow a downward trend to 2040 (Table 4).

Table 4. Ohio River Basin: Consumption of Crude Petroleum by BEAs or BEA Segments,[a] Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

BEA or BEA segment	Estimated 1976	Projected 1980	1990	2000	2020	2040	Average annual percentage change 1976-90	1976-2040
Primary Study Areas	1,880.2	2,663.1	2,015.1	1,844.1	1,441.3	838.8	.50	(1.25)
BEA 55: Evansville, IN	953.5	963.3	1,357.5	1,269.3	971.0	565.1	2.56	(0.81)
BEA 64: Columbus, OH	225.1	465.9	159.4	149.0	114.0	66.3	(2.44)	(1.89)
BEA 66: Pittsburgh, PA	701.6	1,233.9	498.2	465.8	356.3	207.4	(2.42)	(1.89)

Note: The consumption of crude petroleum for 1980 is based on the average annual growth rates of the BEAs for the 1974-80 period provided in the Oak Ridge report, adjusted for the latest projection (series C) made by the U.S. Department of Energy (DOE). The 1990 projections are derived from the national consumption estimated by DOE and distributed to the BEAs by 1985 allocation factors provided by Oak Ridge. In the long run, crude oil consumption is expected to be influenced by the declining domestic supply, and the rates of consumption change in the post-1990 decades are assumed to be two-thirds of the rates of change of crude oil production.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. Department of Energy, Energy Information Administration, Annual Report to Congress, Vol. II, 1977 ed.; Oak Ridge National Laboratory, Energy Availabilities for State and Local Development: Projected Energy Patterns for 1980 and 1985, June 1978; and Table 3.

III. COMMODITY RESOURCES INVENTORY

Production in the PSAs declined during the period 1969-76, from a high of 4,507.5 thousand tons in 1969 to a low of 2,153.8 thousand tons in 1976. This decline is projected to continue at an average annual rate of 0.38 percent per year from 1976 to 1990, and at an average rate of 2.10 percent for the 1976-2040 period.

A. Production Areas

The production of Group III commodities in the PSAs is supplemented by production in Secondary Production Areas (SPAs) located outside the Ohio River Basin. These SPAs are defined as BEAs which are the origins of Group III waterborne movements destined to the Ohio River Basin.

BEA 138 (New Orleans) is the most important SPA. It shipped 456.4 thousand tons of crude to refineries in BEA 55 (Evansville) in 1976 (Table 2). This accounted for nearly three-quarters of total inbound waterborne shipments. Other shipments, for example from BEA 77 (Chicago), transported Canadian and domestic crudes into the ORB.

B. Production Characteristics

The Committee on Reserves of the American Petroleum Institute reported that the total U.S. reserve of crude oil was 30.9 billion barrels at the end of 1976. The reserve decreased by 1.7 billion barrels between 1975 and 1976. During 1976, 1.1 billion barrels of new discoveries were offset by 2.8 billion barrels of crude production. The PSAs are estimated to have added less than one percent of the new discoveries in 1976. Oil reserves in the PSAs are expected to decline in the future.[1]

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1. U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1976 ed. (Washington, D.C.: GPO, 1979), p. 6.

In the short run, the supply of crude oil in the PSAs may not increase significantly as the price of energy rises. In the long run, however, higher selling prices of crudes should increase supply by encouraging the reopening of old wells, more exploration, etc. Also, higher prices of crude will encourage the development of new technologies. For example, computer-assisted drilling technology is being developed to enable operators to drill wells with optimum efficiency. As a result of the rapidly increasing cost of crude oil, there will be numerous other attempts to improve the speed and accuracy of drilling.

Other factors, such as land use restrictions and environmental concerns, will serve as constraints on drilling activities. However, as oil fields in the PSAs are generally remote from population centers, these factors probably will not be significant.

C. Existing Production Levels

The production of crude petroleum in the PSAs decreased rapidly during the past decade. In 1976, production was recorded at 2.2 million tons. This represented less than one-half of the 1969 level. BEA 55 (Evansville) accounted for approximately 97 percent of total PSA production. Consequently, the decrease in oil production in this BEA was the primary cause of the decrease in PSA crude oil supply as a whole (Table 5). Domestic production in SPAs (Secondary Production Areas) also decreased, although at a much lower rate than during the past decade.[1] Imported oil, on the other hand, tripled during the 1969-76 period.

D. Forecasting Procedures and Assumptions

The procedures and assumptions used in the projection of crude oil production are identical to those used in the projection of crude oil consumption (Section II-E). An additional factor is that U.S. production data for the lower-48 states were used in conjunction with distribution factors provided in the Oak Ridge projections. This allowed for the elimination of effects from the newly increased supply of Alaskan North Slope crude oil, which may otherwise have biased the estimates.

E. Probable Future Supply

The supply of crude petroleum in the PSAs is projected to decline slightly from 2.2 million tons in 1976 to 2.0 million tons

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1. U.S. production of crude oil decreased from 9.1 million barrels per day in 1969 to 7.8 million barrels per day in 1976.

Table 5. United States and Ohio River Basin: Production of Crude Petroleum, by BEAS or BEA Segments,[a] Estimated 1969-76

(Thousands of tons)

BEA or BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
United States	498,043.0	519,564.3	510,179.3	510,394.1	496,440.6	473,055.4	451,518.3	439,613.0
Primary Study Areas	4,507.5	3,887.0	3,453.4	2,980.7	2,539.6	2,299.1	2,168.1	2,153.8
BEA 55: Evansville, IN	4,412.3	3,799.8	3,367.1	2,901.8	2,465.6	2,222.7	2,093.7	2,082.7
BEA 64: Columbus, OH	33.9	34.1	32.4	29.3	26.1	29.1	27.1	27.5
BEA 66: Pittsburgh, PA	61.3	53.1	53.9	49.6	47.9	47.3	47.3	43.6

Note: Crude petroleum production by BEA and BEA segment was prepared from county production data reported for the states of Alabama, Illinois, Indiana, Kentucky, Mississippi, Pennsylvania and Tennessee. Production data at a county level were unavailable for Ohio and West Virginia and were estimated from the distribution of earnings in the oil and gas extraction industry for counties reporting in the Census of Mineral Industries and state production figures obtained from the Bureau of Mines. Georgia and Maryland are not crude petroleum producing states.

a. BEA segments defined as counties which are ultimate origins or destinations of *waterborne movements.*

Source: U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1969-76 eds.; Alabama Oil and Gas Board, Production Report: Oil and Gas Fields; Illinois State Geological Survey, County Production of Oil and Gas, 1969-76 eds.; Indiana Department of Natural Resources, Oil Development and Production in Indiana, 1969-72, and 1975-76 eds.; Kentucky State Department of Mines and Minerals, Annual Report, 1969-76 eds.; Mississippi Oil and Gas Board, County Production of Oil and Gas, 1969-76 eds.; Pennsylvania Department of Mines and Minerals, Annual Report, 1970-76 eds.; Tennessee Division of Geology, Oil and Gas Production, 1970-76 eds.; U.S. Department of Commerce, Bureau of the Census, Census of Mineral Industries, 1972 ed.

in 1990 (Table 6). In the later decades, declining oil reserves in the region will serve as an increasing constraint on the supply. As a result, the production of crude oil in the PSAs is projected to decrease at an increasing rapid rate. By 2040, the production will likely be one-quarter of the 1976 level. BEA 55 (Evansville) will continue to be the major producing area in the projection period.

Table 6. Ohio River Basin: Production of Crude Petroleum by BEAs or BEA Segments,[a] Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

BEA or BEA segment	Estimated 1976	Projected 1980	Projected 1990	Projected 2000	Projected 2020	Projected 2040	Average annual percentage change 1976-90	Average annual percentage change 1976-2040
Primary Study Areas	2,153.8	2,097.6	2,041.9	1,846.7	1,232.9	554.9	(0.38)	(2.10)
BEA 55: Evansville, IN	2,082.7	1,834.3	1,842.9	1,666.7	1,112.7	491.8	(0.87)	(2.23)
BEA 64: Columbus, OH	27.5	66.2	61.5	55.6	37.1	16.4	5.92	(0.80)
BEA 66: Pittsburgh, PA	43.6	197.1	137.5	124.4	83.1	36.7	8.55	(0.27)

Note: The production of crude petroleum for 1980 is projected based on the average annual growth rates of the BEAs for the 1974-80 period provided in the Oak Ridge report, adjusted for the latest projection (series C), made by the U.S. Department of Energy (DOE). The 1990 projections are derived from the national production estimated by DOE and distributed to the BEAs by 1985 allocation factors provided by Oak Ridge. For post-1990 decades, the rate of decrease in crude oil production is assumed to be twice that of the preceding period. This assumption implies the complete depletion of the U.S. oil reserve in the year 2100.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. Department of Energy, Energy Information Administration, Annual Report to Congress, Vol. II, 1977 ed. and Oak Ridge National Laboratory, Energy Availabilities for State and Local Development: Projected Energy Patterns for 1980 and 1985, June 1978.

IV. TRANSPORTATION CHARACTERISTICS

In 1976, 63 percent of the crude oil refined in the United States was moved by pipelines, 36 percent of the crudes was transported by water and the remaining one percent was moved by tank cars and trucks. In the PSAs, crude petroleum shipments by water accounted for 0.33 percent of total shipments of all commodities (outbound, inbound and local shipments). During the projection period, waterborne shipments of crude petroleum are expected to fluctuate but to follow a declining trend.

A. Existing and Historical Modal Split

In the PSAs, from 1969 to 1972, barge movements accounted for nearly all the movements of crude oil in the study area. Gross waterway tonnage increased 18 percent in the three-year span and stood at 7.8 million tons in 1972 (Table 1). The development of the pipeline system cut waterborne movements to 4.2 million tons in 1973 and 644 thousand tons in 1974. By 1976, most crude oil movements in the PSAs were by pipeline -- rail recorded no movements, and barge transportation accounted for the remainder, less than 700 thousand tons (Table 7).

B. Intermodal Characteristics

BEAs 64 (Columbus) and 66 (Pittsburgh) recorded consumption of crude oil which was considerably larger than production in 1976. Consequently, substantial inbound movements occurred. In BEA 66, nearly all receipts of crude oil were transported by pipeline. BEA 64, on the other hand, received three-quarters of the crude oil it consumed by barge. BEA 55 (Evansville) is the only PSA which reported excess local production. The excess output was shipped by pipeline to refineries in southwestern Illinois. Barges were used in this BEA, not to move excess local production to other areas, but to transport foreign imported crudes to BEA 55 from BEA 138

Table 7. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Crude Petroleum, by BEAs or BEA Segments,[a] Estimated 1976

(Thousands of tons)

			Shipments (receipts)									
				Water				Rail				
BEA and BEA segment	Production	Consumption	Total net	Net	Inbound	Outbound	Local	Net	Inbound	Outbound	Local	Net truck and pipeline
Primary Study Areas[b]	2,153.8	1,880.2	273.6	(664.5)	664.5	--	--	--	--	--	--	938.1
BEA 55: Evansville, IN	2,082.7	953.5	1,129.2	(497.6)	497.6	--	--	--	--	--	--	1,626.8
BEA 64: Columbus, OH	27.5	225.1	(197.6)	(163.6)	163.6	--	--	--	--	--	--	(34.0)
BEA 66: Pittsburgh, PA	43.6	701.6	(658.0)	(3.3)	3.3	--	--	--	--	--	--	(654.7)

Note: Gross and net waterborne and rail shipments (receipts) were determined for 1976 from U.S. Army Corps of Engineers waterborne commerce data and Interstate Commerce Commission railroad waybill data. Total net shipments (receipts) were determined by subtracting consumption from production. Net pipeline shipments (receipts) were determined by subtracting net waterborne and rail shipments (receipts) from total net shipments (receipts).

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

b. Primary Study Area shipments equal inbound, outbound and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each of the BEA segments.

Source: Estimated production and consumption from Tables 3 and 5. Water and rail shipments (receipts) compiled by RRNA from Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.

(New Orleans). Some domestic crudes arrived by barge from BEA 38 (Tallahassee) for transshipment via pipelines located in BEA 55. Thus, barge and pipeline are not competing, but are, rather, complementary transport modes in this instance.

C. Factors Affecting Modal Choice

The historical shift of modes clearly indicates the superiority of transporting crude oil by pipeline, as compared with barge and other modes. George M. Stafford, Chairman of the Interstate Commerce Commission, stated in testimony before a Senate Special Subcommittee in 1973 that: "Today there are so few complaints and so few problems that I must say (the pipelines are) one of the best run transportation systems we have."[1] The timeliness and low cost of pipeline deliveries are the principal reasons.

C-1. Transport Time

Pipelines can transport crudes directly from production to consumption sources. Discussions with industrial authorities reveal that crude petroleum is almost always delivered to refineries on schedule (usually to the minute). Barges, on the other hand, usually must face weather conditions, variations in river water levels, and other factors which cause undesirable fluctuations in delivery time. As a result, refineries dependent on barge transportation are required to have a large and costly storage facility to avoid idle capacity due to delivery delays.

C-2. Transport Cost

Compared with barge, pipelines are very cost efficient. On the average, pipeline rates are about one-half those of barges, one-quarter those of railroads, and one-twentieth those of truck. Most pipelines have been built by private oil and pipeline companies.

However, pipelines are not always available to transport crude oil. They are highly capital intensive, and a typical pipeline requires $4 of capital investment to generate $1 in revenue. This is in contrast to the average U.S. requirement of only 50 cents to

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1. Market Performance and Competition in the Petroleum Industry, Hearings before the Special Subcommittee on Integrated Oil Corporations of the Senate Committee on Interior and Insular Affairs, 93rd Congress, 1st Session 896 (1973).

generate the same $1 in revenue.[1] Such a large investment requirement, therefore, requires a large volume of throughput to be profitable. Areas producing and consuming small amounts of crude oils must continue to rely on barge and other means of transportation.

D. Forecasting Procedures and Assumptions

Currently, there are more than 220,000 miles of crude oil and petroleum products pipelines in the United States. These include 76,000 miles of crude trunk lines and 69,000 miles of crude oil-gathering lines. Crude oil is delivered to refineries in the PSAs by the Ashland (24 inches diameter) and Mid-Valley (20 inches diameter) pipelines (Appendix Map A-3). In addition, there are numerous crude oil-gathering lines which are less than six inches in diameter in BEAs 55, 64 and 66.

Because of the high cost of pipeline construction and declining petroleum resources in the PSAs, it is expected that no additional pipelines will be built. Given the assumption that there will be no change in the relative prices of transport modes, the future modal split is assumed to aproximate the 1976 pattern. The relationship between inbound and net waterborne shipments has been projected to be constant. Additional explanations of forecasting procedures and assumptions are presented in Table 8.

E. Probable Future Modal Split

Based on the factors discussed above, it is expected that the future modal split will not vary from the 1976 patterns for any PSA (Table 8). As crude oil supply and consumption decrease, no new investment in pipelines and pump stations will take place, and the share of pipeline transportation will remain constant.

F. Probable Future Waterway Traffic Flows

The BEA-to-BEA waterborne traffic projections are presented in Table 9. Growth indices derived from the traffic projections are presented in Table 10.

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1. Howrey and Simon, Pipelines Owned by Oil Companies Provide a Pro-Competitive and Low-Cost Means of Energy Transportation to the Nation's Industries and Consumers (Washington, D.C.: n.p., 1978).

Table 8. Ohio River Basin: Production, Consumption, and Shipments by Mode of Transportation of Crude Petroleum, Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

	Estimated	Projected					Average annual percentage change	
	1976	1980	1990	2000	2020	2040	1976-90	1976-2040
Production	2,153.8	2,097.6	2,041.9	1,846.7	1,232.9	554.9	(0.38)	(2.10)
Consumption	1,880.2	2,663.1	2,015.1	1,884.1	1,441.3	838.8	0.50	(1.25)
Net shipments (receipts)	273.6	(565.5)	26.8	(37.4)	(208.4)	(283.9)	(15.29)	(0.06)
Net waterborne	(664.5)	(847.0)	(826.8)	(772.8)	(591.2)	(344.2)	1.57	(1.02)
Net rail	--	--	--	--	--	--	--	--
Net truck and pipeline	938.1	281.5	853.6	735.4	382.8	60.3	(0.68)	(4.20)
Gross waterborne shipments:								
Outbound	--	--	--	--	--	--	--	--
Inbound	664.5	847.0	826.8	772.8	591.2	344.2	1.57	(1.02)
Local	--	--	--	--	--	--	--	--
Total	664.5	847.0	826.8	772.8	591.2	344.2	1.57	(1.02)

Note: Projected net shipments (receipts) were determined by subtracting projected consumption from projected production. Projected modal split would remain constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise. Gross waterborne shipments equal the sum of inbound, outbound and local shipments. Gross inbound shipments (total receipts) were projected by assuming that these shipments would increase at the same rate as consumption except when data, analyses and conversations with industrial authorities indicated otherwise.

Source: Tables 4, 6, and 7; Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

Table 9. Ohio River System: BEA-to-BEA
Waterborne Traffic of Crude Petroleum
Actual 1976 and Projected 1980-2040, Selected Years

ORIGIN BEA	DESTINATION BEA	COMMODITY GROUP	HUNDREDS OF TONS 1976	1980	1990	2000	2020	2040
038	055	03	412	416	587	548	420	244
077	064	03	857	1774	607	567	434	254
114	064	03	256	530	181	169	130	75
138	055	03	4564	4610	6499	6075	4646	2706
138	064	03	523	1082	371	347	265	153
140	066	03	33	58	23	22	17	10
		TOTAL	6645	8470	8268	7728	5912	3442

Source: Robert R. Nathan Associates, Inc.

Table 10. Ohio River System: Growth Rates of Crude Petroleum Waterborne Commerce, BEA to BEA, Projected 1976-2040, Selected Years

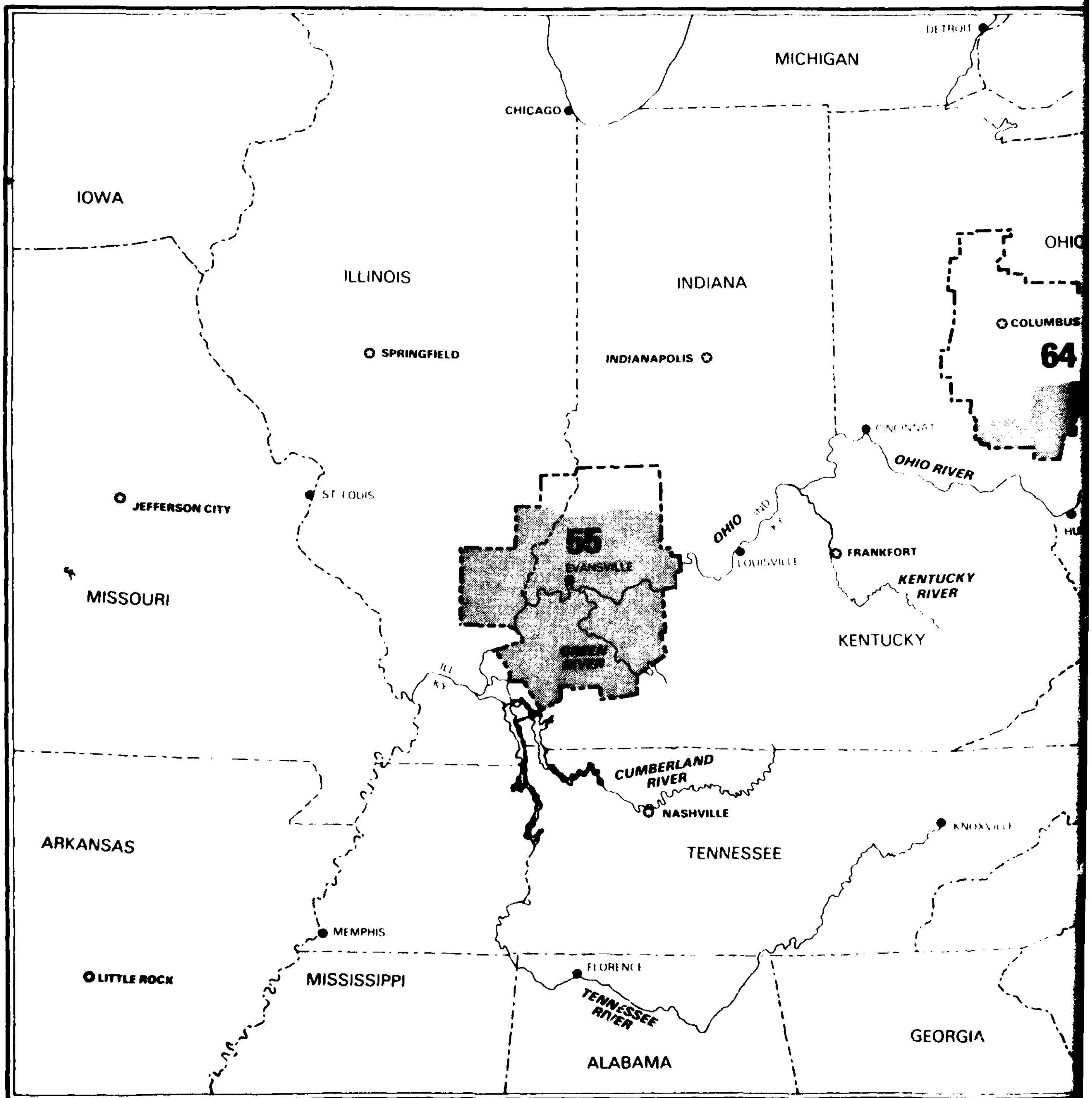
BEA Pair[a]	Group No.	Index Value[b]	Year[c] 1976	1980	1990	2000	2020	2040
038055	03	412	1000	1010	1425	1330	1019	592
077064	03	857	1000	2070	708	662	506	296
114064	03	256	1000	2070	707	660	508	293
138055	03	4564	1000	1010	1424	1331	1018	593
138064	03	523	1000	2069	709	663	507	293
140066	03	33	1000	1758	697	667	515	303

a. The first three digits indicate the BEA of origin; the last three digits indicate the BEA of destination.
b. Hundreds of tons.
c. Growth rates are reported such that 1000 equals the index value reported in the third column.
Source: Robert R. Nathan Associates, Inc.

Briefly, the average annual growth rate of net waterborne shipments in the ORS will be 1.57 percent for the 1976-90 period. In the following decades, lower production and consumption will lead to lower waterborne shipments, such that the 1976-2040 average annual rate of decline will be 1.02 percent. There will be no outbound and local movements. Inbound waterborne shipments will change at the same rates as the net waterborne shipments.

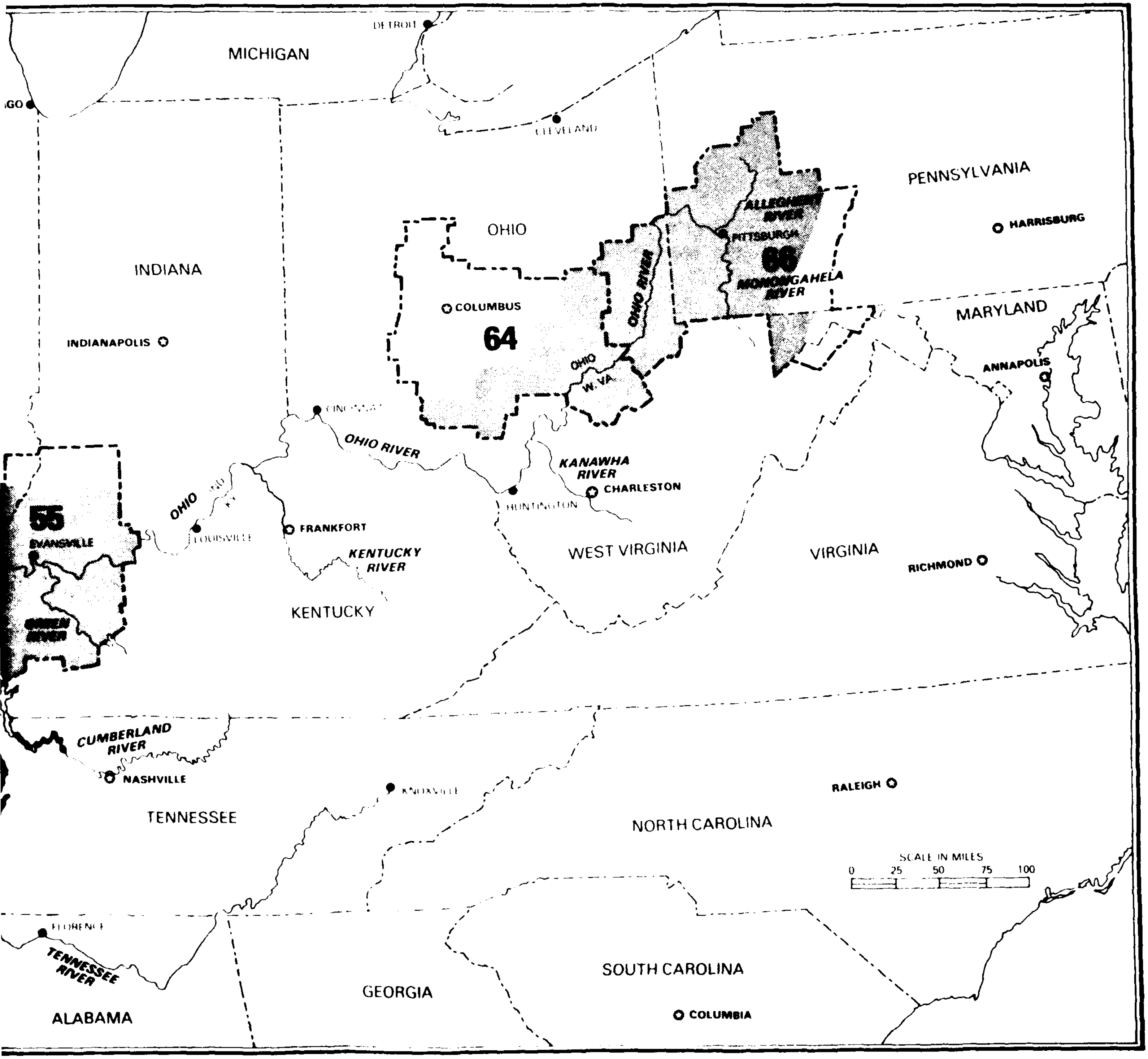
V. APPENDIX

MAP A-1. OHIO RIVER BASIN: PRIMARY STUDY AREAS FOR CRUD
(BEAs AND BEA SEGMENTS)



SOURCE: Robert R. Nathan Associates, Inc.

MAP A-1. OHIO RIVER BASIN: PRIMARY STUDY AREAS FOR CRUDE PETROLEUM (BEAs AND BEA SEGMENTS)



■ Primary Study Areas

Table A-1. Ohio River Basin: Primary Study Areas for Crude Petroleum

(BEAs and BEA segments)

BEA 55 (segment): Evansville, IN

Caldwell, KY
Crittenden, KY
Daviess, KY
Hancock, KY
Henderson, KY
Hopkins, KY
McLean, KY
Muhlenberg, KY
Ohio, KY
Union, KY
Webster, KY
Edwards, IL
Gallatin, IL
Hamilton, IL
Saline, IL
Wabash, IL
White, IL
Dubois, IN
Gibson, IN
Perry, IN
Pike, IN
Posey, IN
Spencer, IN
Vanderburgh, IN
Warrick, IN

BEA 64 (segment): Columbus, OH

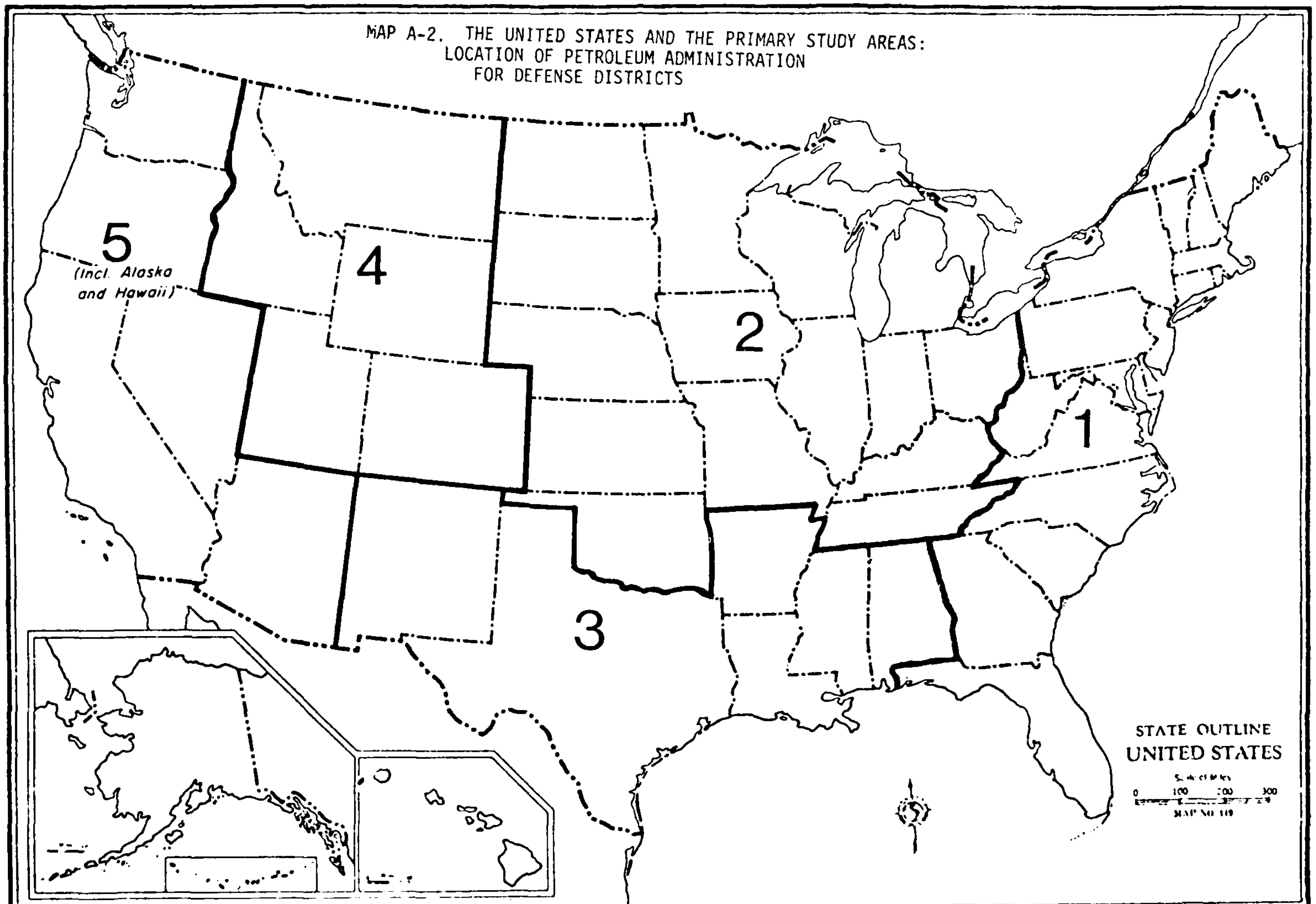
Athens, OH
Guernsey, OH
Hocking, OH
Jackson, OH
Morgan, OH
Noble, OH
Pike, OH
Vinton, OH
Washington, OH
Pleasants, WV
Ritchie, WV
Wirt, WV
Wood, WV

BEA 66 (segment): Pittsburgh, PA

Garrett, MD
Belmont, OH
Harrison, OH
Jefferson, OH
Monroe, OH
Allegheny, PA
Armstrong, PA
Beaver, PA
Butler, PA
Clarion, PA
Fayette, PA
Greene, PA
Indiana, PA
Washington, PA
Westmoreland, PA
Brooke, WV
Hancock. WV
Marshall, WV
Ohio, WV
Tyler, WV
Wetzel, WV

Source: Robert R. Nathan Associates, Inc.

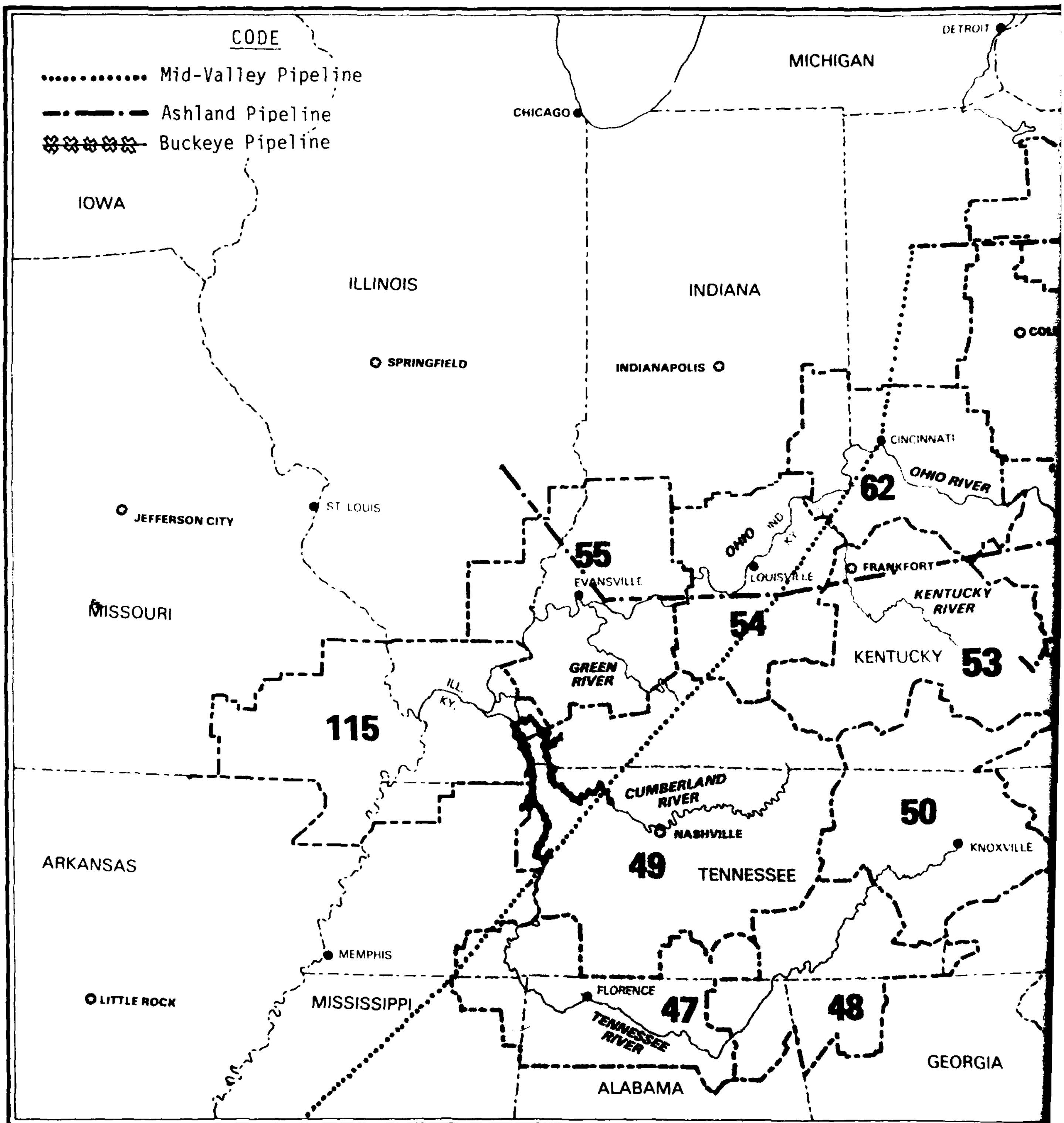
MAP A-2. THE UNITED STATES AND THE PRIMARY STUDY AREAS: LOCATION OF PETROLEUM ADMINISTRATION FOR DEFENSE DISTRICTS



Source: U.S. Department of Energy, Energy Data Report: Crude Petroleum, Petroleum Products, and Natural Gas Liquids, 1976 ed.

Primary Study Areas

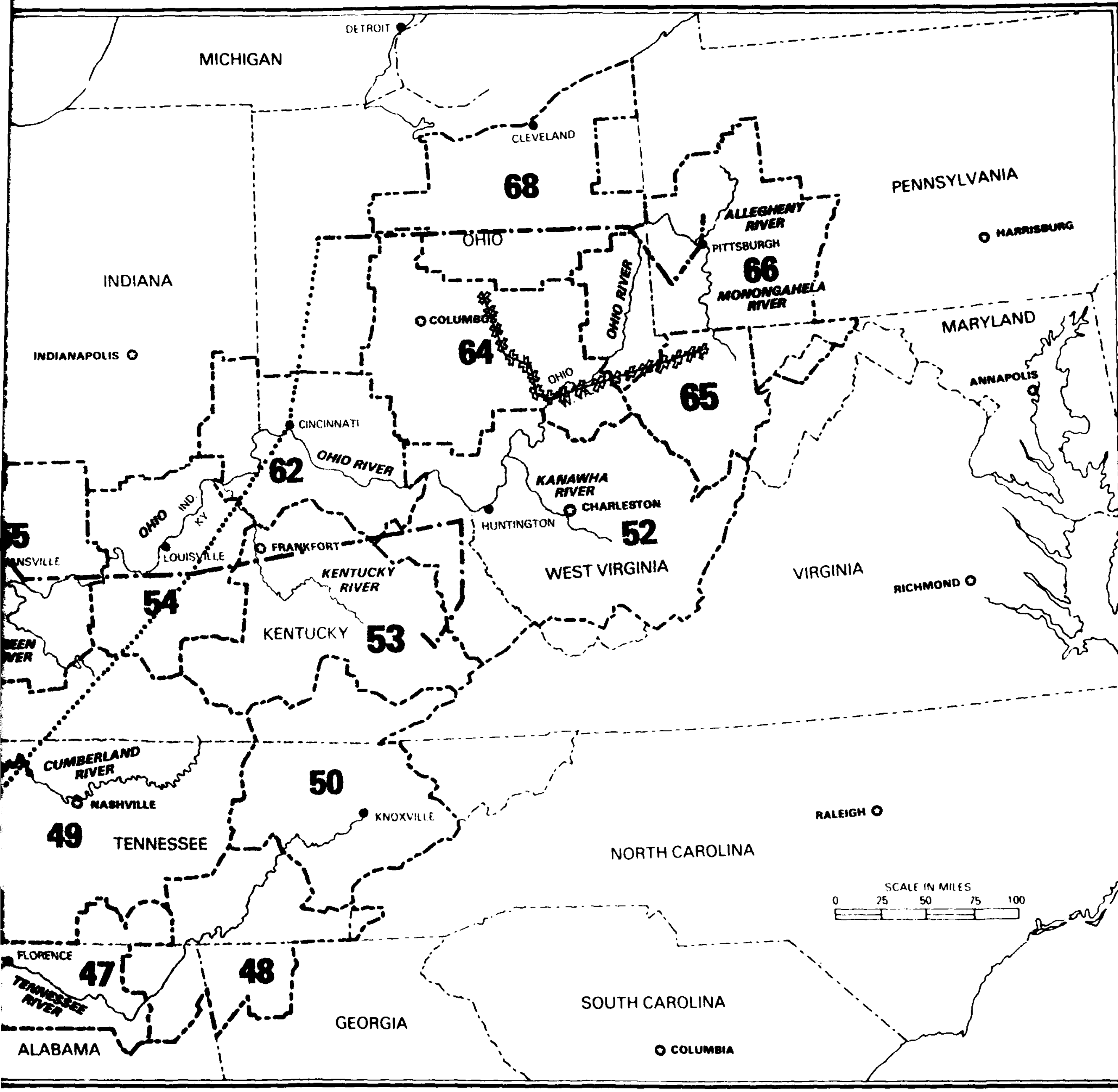
MAP A-3. CRUDE OIL PIPELINES IN THE OHIO RI



Source: Crude Oil Pipelines in the United States, 1979 ed., American Petroleum Institute.

Primary Study Areas

AP A-3. CRUDE OIL PIPELINES IN THE OHIO RIVER BASIN



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Association of Oil Pipelines, Washington, D.C.

Branch of Petroleum Production and Processing, Department of Energy, Washington, D.C.

Commission on Energy and Environment, Charleston, West Virginia.

Consumption Office, Energy Information Administration, Department of Energy, Washington, D.C.

Independent Petroleum Association, Washington, D.C.

Information Office, Federal Energy Regulatory Commission, Washington, D.C.

Marathon Oil, Inc., Louisville, Kentucky.

Mid-Contential Oil & Gas, Washington, D.C.

Oil Pipeline Board, Federal Energy Regulatory Commission, Department of Energy, Washington, D.C.

Office of Energy Data Interpretation, Department of Energy, Washington, D.C.

Office of Pipeline Safety, Department of Transportation, Washington, D.C.

Operation and Resource Allocation Office, Department of Energy, Washington, D.C.

People's Gas Company, Washington, D.C.

Pipeline Producer Regulatory Office, Department of Energy, Special Assistant, Washington, D.C.

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Sohio Petroleum Company, Washington, D.C.

Triangle Refinery, Louisville, Kentucky.

U.S. Department of the Interior, Bureau of Land Management, Washington, D.C.

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